Stanford Telecommunications, Inc.

8 January 1995

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Office of the Secretary
Federal Communications Commission
Washington, D.C. 20554

Subject: Enhanced 911 Requirement Established by FCC Docket No. 94-102

Dear Sirs,

Please find enclosed 10 copies of a submittal relative to the new enhanced 911 requirement established by FCC Docket # 94-102

Sincerely
Herman A Bustamante
Herman A. Bustamante
Technical Director

Stanford Telecommunications, Inc.

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Federal Communications Commission
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Subject: Enhanced 911 Requirement Established by FCC Docket No. 94-102

Dear Sirs,

Stanford Telecommunications, Inc. is participating in the TIA TR 41.6 Wireless Users Premises Equipment subcommittee in the development of a new PCS standard for the unlicensed band. Our system is based on our patented Orthogonal CDMA (OCDMA) telephone system concept. It offers significantly improved total system performance as compared to other systems, e.g., the IS-95 system being developed for use in the cellular telephone system. One major significant difference in our system concept is the implementation of completely synchronous signal operation in both the inbound and outbound links, which other systems do not provide. This permits the achievement of improved system performance in terms of both reduced transmitter power as well as increased system capacity.

The principle reason for addressing this committee, however, has nothing to do with this realized improved system performance. The reason for this letter has to do with the requirement for future wireless telephone systems to provide the enhanced 911 emergency call capability as described in the Federal Communications Commission Notice of Proposed Rule Making, CC Docket No. 94-102, RM-8143. **The wireless users premises equipment system for which we are presently developing the standard for the TR 41.6 committee provides all the requisite characteristics and performance requirements necessary to satisfy all enhanced 911 system requirements.**

This letter describes, in top level system form, the characteristics of the proposed system and how they satisfy the enhanced 911 (ENH911) system requirements. Section 1.0 introduces the basic telephone system concept. Section 2.0 describes the method of signal synchronization and channel sounding used for combating channel multipath and fading. These two sections can be skipped by anyone familiar with the basic system. Section 3.0 introduces the use of GPS for system timing and frequency stability only. It must be emphasized that GPS navigation is not used in this system. Section 4.0 describes how the proposed system automatically provides all the desired features required to satisfy the enhanced 911 requirement.

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1.0 Telephone System Concept

The system is designed around the concepts of orthogonal CDMA. A total service area for the system can be defined which may consist of a floor of a building, the entire building, or a campus consisting of many buildings. Microcell sites with a communication range on the order of 30 to 50 meters are established each with a base station capable of supporting a group of local users which may roam out of the cell while other users may roam into the cell as they walk around within the total system serviced area. All signals within a cell are mutually synchronous in both the inbound and outbound links. The system operates with 10 ms time division duplex frames, 5 ms outbound followed by 5 ms inbound. The 5 ms outbound portion of the 10 ms frame is here referred to as the HS0 portion. The 5 ms inbound portion of the 10 ms frame is here referred to as the HS1 portion. The frame structure is illustrated in Figure 1.

There is a master frame structure consisting of 64 frames, or 640 ms time duration. This provides a means of real time access to 64 handsets via the order wire channel if desired. This structure provides a permanent means of access to users not presently in the system. The master frame structure is shown in Figure 2.

All cell site base stations are synchronized to the GPS system to minimize initial errors, to simplify handover operations, and so as to have a well defined timing reference standard throughout the system. Each carrier contains 32 mutually orthogonal CDMA signals. Of these 1 is a dedicated order wire channel used for the purpose of permitting a user initial entry into the system, call establishment, and simplified handover operations. The other 31 channels are full duplex voice or data channels as required at any time. Within each of these 31 voice channels there is also an in band control channel provided for the purpose of control and adjustment of operating conditions during the performance of a voice conversation without interruption or disturbance of the ongoing voice conversation. Recall that the system has a master frame structure of 64 frames length. The order wire channel operates with each user using one frame in turn such that there is excess capacity and twice as many users can be addressed in real time via the order wire channel than can be accommodated within the voice channel structure. The 31 voice channels are fixed assigned to a given user on an "as needed" basis. Once the call is completed the channel can be reassigned for use by any other user.

The orthogonality of the 32 channels is established by the use of a family of 32 Radamacher-Walsh (RW) functions, one being used for each channel. These RW functions are 32 chips long and the chipping rate is 32 times faster than the channel transmitted data rate. Thus, the RW function is equal to a data symbol duration and a spreading ratio of 32 results, providing a processing gain of 32 (or 15 dB) against narrow band interference signals. A longer PN code is overlaid on top of the RW codes operating at the same chipping rate. This overlay PN code produces a finely divided spectrum with a reduced power spectral density acceptable for use in both the unlicensed PCS and the ISM bands. The modulation technique used is QPSK for the data and BPSK for the spreading code.

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2.0 System Synchronization and Channel Sounding

The essential features of the system are signal synchronization and continued channel operation even in the presence of multipath. Stable synchronization is guaranteed by the use of a signal synchronization preamble signal transmitted by the base station and the individual handsets at the beginning of their respective signal transmit periods as shown in Figure 1. The duration of the various time intervals is shown in either data symbol intervals or spreading code chip intervals. Those labeled in spreading code chip intervals have the subscript "c" identifying them. Those portions labeled in code chip intervals are signal gaps between successive transmit periods.

The preamble from the base station consists of two 6 data symbol long segments at the beginning of the outbound signal portion of the TDD frame. Only one signal is transmitted by the base station during this interval so that the total power of the 32 channels can be allocated to this one signal. The handsets are thereby provided a very high signal to noise signal from which to derive synchronization. The handsets have two orthogonaly polarized antennas. Each antenna alternately receives one 6 symbol long segment and the antenna providing the better signal to noise condition is selected for operation during the entire following 10 ms frame interval.

The preamble from the handsets occurs in the equivalent time interval during the inbound portion of the frame. As noted above, the handset antenna selected using the base station preamble reception is used throughout the frame for both outbound signal reception and inbound signal transmission. This is valid because of channel symmetry.

3.0 GPS System Synchronization and Timing

The incorporation of GPS system synchronization at all base stations provides a very stable signal frequency, very stable signal timing, and simplifies the performance of channel handover and mobility management. What is most important with respect to the enhanced 911 requirement is the improved performance of signal timing measurement capability.

The GPS system makes use of digital codes to perform ranging measurements and derive navigation solutions. This capability is not made use of here. However, the same capability exists in the proposed PCS system since the orthogonal spreading codes are digital codes whose time offset can be used to define range offset in the form of signal time of arrival measurements (TOA). The RW codes are of length 32 with a 1.5 microsecond chip duration. A tracking accuracy of 3 % is achievable with the resultant high signal to noise ratios. This provides a range measurement accuracy of approximately 45 nanoseconds, or approximately 45 feet, which is more than adequate for the telephone system envisioned. By providing a means of deriving range, or TOA information, to each of three base stations, the exact location of the transmitting handset can be determined unambiguously.

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4.0 Enhanced Emergency 911 (ENH911) System Implementation

An enhanced emergency 911 (ENH911) handset location capability can be provided optionally. The system concept is as follows.

In the event an ENH911 call is initiated by the user of a handset of the system, the handset automatically changes mode of operation. All of the preceding system description remains valid with respect to the transmission of data or voice. The operational procedures are unchanged including all MAC, DLC, and network related functions. What changes is the inclusion, once per master frame, of a 100 ms burst of a sequence of half slot transmissions of unmodulated overlay PN sequence and RW OCDMA code emanating from the handset only. This is illustrated in Figure 3, where HS 0, and HS 1 represent half slot 0 and half slot 1 in the standard transmission format. This pattern is repeated once per master frame. The 540 ms interval between ENH911 bursts will be normal voice communications.

A message will be contained as part of the 1600 bps control channel data to the RFP from the handset alerting the base station that an ENH911 call is in progress. Upon reception of this information by the base station, it alerts the other base stations in the immediate area surrounding the receiving primary base station.

All base stations will be instrumented with matched filter receivers which can process the received OCDMA and overlay PN code spread signals so as to derive accurate time of arrival (TOA) data from them. At least three of the base stations within range of the transmitting handset will be assigned to derive TOA data from the ENH911 signal. Accurate initial frequency, timing, and OCDMA code and overlay PN code data is provided to the matched filter receiver by the standard data/voice receiver. By performing smoothing, e.g., Kalman filtering of the derived measurements over an extended time interval, and by use of triangulation of measurements from all participating base stations, very accurate position determination can be performed on the handset transmitting the ENH911 signal.

Note the characteristics automatically provided by the system.

1) The user has access to the system via the order wire channel at all times. If a voice channel is available, the user is assign it immediately. If a channel is not available, the user is identified to be initiating a 911 call and is given the next available channel on a priority basis.
2) The 911 call is monitored by all base stations capable of receiving its signal and a navigation solution is derived determining the users location.
3) A range measurement is always possible even if the nearest base station may have its signals blocked momentarily. So long as range measurements can be made a reasonable position determination should be possible to within a few tens of meters.

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This is, of course, a very concise description of the system and the enhanced 911 concept. Should you have any questions regarding the system or any aspect thereof, please do not hesitate to call. We would be pleased to discuss it in detail with you. In addition, should you feel that a face to face meeting would be desirable we would be pleased to consider this. You can contact either myself at the numbers given below, or Dr. Horen Chen at 408-745-2509. We look forward to hearing any comments you may have on our proposal.

Sincerely,

Herman A. Bustamante

Herman A. Bustamante
Technical Director

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